II. Methods

This assessment compares water use to stream flow conditions. Water use data are reported to the Department on a regular basis by registered users. Stream flow data are available from USGS sources for most of the Designated Rivers. The assessment requires aggregating water use at stream locations. The result is a comparison between aggregate water use and some standards for water use, either PISF values or a set of placeholders for the PISF called General Standards.

A. Water Use Estimates

Water use data are available for registered water users from the NHDES Water Use database. Registration is required under the Water Use Registration and Reporting Rules for water users who use more than 140,000 gallons during a week (13.9 gpm on a continuous basis) in any year. Monthly water use data are self-reported by water users to the Department either quarterly or annually depending on water use type. The Department records these data in the Water Use Database and a data link to the Department's Geographic Information System (GIS) coverages is updated periodically. This annual report uses the monthly water use estimates from the data linked to the GIS coverage on April 14, 2004.

Every effort was made to use reported data including individual queries to the Water Use data base to retrieve late entries for this report however in a number of instances data was not reported for the 2003 calendar year. To complete the data set for 2003, missing water use data was populated by interpolation from the months before and after the missing point or by using trends or averaged data from previous years' water use reports as seemed most appropriate. The choice of method was based on the most reasonable expectation of water use given the Department's understanding of the water use type.

Under the Instream Flow Rules, monthly aggregate water use must be assessed versus average monthly streamflow. Aggregate water use is defined as the total water use by all affected water users at and upstream from any location on a designated river, being the difference between the sum of water withdrawals and the sum of measured, registered water returns. Measured registered water returns exclude water uses such as irrigation, where the intent is for the water to be taken up and used by the plants. Also, excluded are uses where water losses or water return cannot or is not measured. However, water returns were calculated as equal to the inflow where water use is a pass-through use without expectation of losses such as at a hydroelectric dam.

Water withdrawals and returns may occur directly on the Designated River or on a tributary. Effects of withdrawals and returns were assessed at every impact point on the Designated River. An impact point is where the water use affects the Designated River. A withdrawal or return directly at the Designated River has an impact point at that location. If the water use is a well within 500 feet of the Designated River, the impact point is the point where a surficial flow line from the well meets the Designated River. This is meant to represent the point where groundwater would enter the River if the well were not withdrawing water. Water use that does not occur directly on the Designated River is migrated downstream along the nearest tributary until it meets the Designated River. The impact point is where the tributary intersects the Designated River because this is where the water use impact occurs. One or more affected water users may exist on a tributary resulting in a single impact point for all the upstream water use.

B. Aggregate Water Use Estimates

Water use on the Designated River is aggregated at each impact point and also at each end of the Designated River by finding the difference between the sum of water withdrawals and the sum of measured registered water returns for all upstream sources and discharges. Water use by intermediate users, such as an industry receiving water from a municipal public water supply, are transfers of water. A transfer of water is not aggregated so as not to double count. Transferred water is part of the withdrawal or return values reported for the source or discharge. The aggregate water use is reported in cfs.

C. Stream Flow Estimates

Monthly stream flows were estimated for the impact points on the Designated Rivers. Monthly stream flows are used to determine the General Standard criteria for each impact point. Stream flows were interpolated or extrapolated from USGS stream flow gages. Stream flow estimates in this report rely on the concept that streamflow will vary uniformly with drainage area. This is not always true especially as one goes to much larger or much smaller drainage areas than the reference data. Streamflow estimates will be most accurate at locations closest to the gage. Future reports are expected to measure stream flow using regression methods to define monthly stream flow at impact points.

Stream Flow Data Source

Daily streamflow values were taken from the USGS website which provides data on a provisional basis (http://waterdata.usgs.gov/nh/nwis/current/?type=flow), meaning they are preliminary and have not received final approval by USGS. Daily average streamflow data in cfs were downloaded from the USGS web pages then imported to Excel worksheets.

Gages are first selected from the active, total record stream gages on a Designated River. Partial record gages may be used where no total record gages are available. Partial record gages may not be well calibrated for measuring low flows because their main use is measurement of high flows. Where gages on the Designated River were not available, surrogate gages within the Water Management Planning Area were used, or as a final resort, gages in other similar watersheds were used where no gages were active in the Water Management Planning Area.

Where a surrogate gage was necessary, gages were identified that are within watersheds similar to the watersheds of the ungaged Water Management Planning Area. Drainage basin size, elevation, and location were used as the criteria to identify a set of possible surrogate gages. Surrogate gages were used in two ways. One way was to compare the surrogate gage's flow to a historically active gage in the WMPA using linear regression. The regression equation was then used to create data for the historical data location using 2003 data from the surrogate gage. The second use was to use the surrogate gage directly with compensation for drainage basin size. The gages used for the fourteen Designated Rivers are identified below.

In some cases, where there is more than a single gage measuring the Designated River, there are different cfsm values for various segments of the Designated River. On occasions, such as at the confluence of the Winnipesaukee River with the Upper Merrimack Designated River, data from gages on a tributary was used to assist in defining the streamflow assessment.

Gages for each DR for 2003 GS Flow transposition

Ashuelot

01158000	ASHUELOT RIVER BELOW SURRY MT DAM, NEAR KEENE, NH
01160350	ASHUELOT RIVER AT WEST SWANZEY, NH
01161000	ASHUELOT RIVER AT HINSDALE, NH

Cold
Surrogate station at

01154000	SAXTONS RIVER AT SAXTONS RIVER, VT

Connecticut

01129200	CONNECTICUT R BELOW INDIAN STREAM NR PITTSBURG, NH
01129500	CONNECTICUT RIVER AT NORTH STRATFORD, NH
01131500	CONNECTICUT RIVER NEAR DALTON, NH
01138500	CONNECTICUT RIVER AT WELLS RIVER, VT
01144500	CONNECTICUT RIVER AT WEST LEBANON, NH
01154500	CONNECTICUT RIVER AT NORTH WALPOLE, NH

Contoocook

01085500	CONTOOCOOK R BL HOPKINTON DAM AT W HOPKINTON, NH
01086000	WARNER RIVER AT DAVISVILLE, NH
01087850	CONTOOCOOK RIVER AT RIVER HILL, NEAR PENACOOK, NH

Exeter

1073587	EXETER RIVER AT HAIGH ROAD, NEAR BRENTWOOD, NH

Isinglass
Surrogate stations at

01073500	LAMPREY RIVER NEAR NEWMARKET, NH
01072800	COCHECO RIVER NEAR ROCHESTER, NH.
01073000	OYSTER RIVER NEAR DURHAM, NH
01073587	EXETER RIVER AT HAIGH ROAD, NEAR BRENTWOOD, NH

Lamprey

01073500	LAMPREY RIVER NEAR NEWMARKET, NH

Merrimack (Lower)

01092000	MERRIMACK R NR GOFFS FALLS, BELOW MANCHESTER, NH

Merrimack (Upper)

01081500	MERRIMACK RIVER AT FRANKLIN JUNCTION, NH

Pemigewasset

01075000	PEMIGEWASSET RIVER AT WOODSTOCK, NH
01076500	PEMIGEWASSET RIVER AT PLYMOUTH, NH
01081000	WINNIPESAUKEE RIVER AT TILTON, NH

Piscataquog
Surrogate stations at

01094000	SOUHEGAN RIVER AT MERRIMACK, NH
01082000	CONTOOCOOK RIVER AT PETERBOROUGH, NH
01085500	CONTOOCOOK R BL HOPKINTON DAM AT W HOPKINTON, NH

Saco

01064500	SACO RIVER NEAR CONWAY, NH

Souhegan

01094000	SOUHEGAN RIVER AT MERRIMACK, NH

Swift

1064500	SACO RIVER NEAR CONWAY, NH

Monthly Stream Flow Data Processing

Monthly mean streamflows were estimated for 2003 using the daily mean streamflow data downloaded for the selected gages from the USGS website to an EXCEL worksheet. Some gages have data missing for one to as many as all days in a month. This frequently is the result of iced-over conditions, which render the rating curve inaccurate. Missing daily data were replaced with Period-of-Record mean daily streamflow values or with linearly interpolated values if there were fewer than five consecutive days missing. Monthly average values were then calculated from the daily values for 2003 populated with these actual, interpolated, or historical mean daily values. In some cases POR mean monthly values were used.

Where no active gages were identified in the Water Management Planning Area, such as for the Cold River, surrogate data from other gages were used. The Cold River gage is inactive. A surrogate data set was created for 2003 from a nearby gage on the Saxton River in Vermont. These gages have similar basin size, elevation, and location. They also have 38 years of contemporaneous data collection. Monthly average flows for each gage were paired for the period when both gages were active. A comparison of flows was then conducted by running a linear regression on monthly average flows for the gages' mutually active period to calculate slope and intercept values. Monthly average stream flows for the inactive gage on the Cold River were then estimated for 2003 using the monthly averages from the surrogate gage calculated with the regression equation. Where no historical gage was available for regression, data from a surrogate gage was adopted from nearby watersheds. The surrogate stream flow was usually averaged from at least two gages, which was converted to a cfsm value and then applied to the target river.

Stream flow at each impact point is determined by areal transposition methods. Monthly average stream flows in cubic feet per second at a gage were converted to cfsm by dividing the monthly stream flow by the gage's drainage area in square miles. The drainage areas of each impact point can then be multiplied by this flow value to yield the average monthly stream flow at each location. Between two gages, where more than a single gage might apply to an impact point, interpolation of the stream flow at each gage is used. The watershed area between the two gages is measured and the ratio of that area above and below the impact point is used as the ratio of the monthly stream flow used from each gage.

$$AMS_{(ip)} = \left\{\left(\left[1-\left(\left[DA_{(ip)}-DA_{(ug)}\right] / \left[DA_{(dg)}-DA_{(ug)}\right]\right)\right]*AMS_{(ug)}\right) + \left(\left[1-\left(\left[DA(dg)-DA(ip)\right] / \left[DA(dg)-DA_{(ug)}\right]\right)\right]*AMS_{(dg)}\right)\right\}* DA_{(ip)}$$

Where:
$AMS_{(ip)}$ = average monthly stream flow at an impact point between gages
$DA_{(ip)}$ = drainage area of the impact point in square miles
$DA_{(ug)}$ = drainage area of the upstream gage in square miles
$DA_{(dg)}$ = drainage area of the downstream gage in square miles
$AMS_{(ug)}$ = average monthly streamflow of the upstream gage in cfsm;
$AMS_{(dg)}$ = average monthly streamflow of the downstream gage in cfsm

C. General Standard Determination

The General Standard is a quantitative way to evaluate water use among streams of different sizes and characteristics. When the rivers have protected flows established for them, water use will be assessed based on the the protected flows instead of the General Standard. The General Standard is not a Protected Instream Flow, but instead is a set of criteria for evaluating water use in watersheds where a protected flow has not yet been established. Water use is compared to the General Standard, which is derived from monthly stream flow per unit area. When stream flow is higher, the General Standard for water use is higher. When aggregate water use exceeds the General Standard, the stream segment is not in compliance with the General Standard. The General Standard acts as a means of assessing water use versus stream flow that is comparable on all the Designated Rivers. Rivers that are not in compliance are the highest priorities for developing protected instream flows.

The four water use criteria in the General Standard are expressed as values in cfsm making these values drainage basin-size dependent. To calculate the General Standard for the impact points in the watershed, the monthly streamflow at a gage location is converted to cfsm by dividing the flow by the gage's drainage area. Streamflow in cfsm for each impact point is then compared to the four tiers of the General Standard as described in Env-Ws 1903.02 (c) of the Instream Flow Rules, which are listed above.

The General Standard should not be interpolated between gages. This would result in hybridized General Standard values in those cases where the General Standard varied between the two gages. This can happen where gages show different stream flows in sub-basins within the larger watershed. In these cases, the stream flow is interpolated for the impact point using the method above and the General Standard is defined based on this value.

The General Standard includes a reference to 7Q10 in the lowest of the criteria. The stream flow statistic known as 7Q10 represents the flow that is the lowest 7-day average flow with a recurrence interval of 10 years. Values for each gage were usually taken from values derived by USGS for gages with sufficient periods of record. These data and the USGS methods can be found at http://www.des.state.nh.us/rivers/instream/Archive/pourpt/Gage_Pourpoint_20010327.xls and http://www.des.state.nh.us/rivers/instream/Archive/pourpt/compute.htm. Additional values were taken from USGS WRI 02-4298, "Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams." In some cases, a value for 7Q10 was averaged from nearby gages.

D. Comparison of Aggregate Water Use with the General Standard

The Aggregate Water Use and the General Standard criteria are determined for each impact point on the Designated River. At the locations and months that the Aggregate Water Use exceeds the General Standard criteria, the river is not in compliance with the General Standard. These locations and times are identified in the individual river reports for each WMPA. Graphs for each month show the General Standard with the impact point water use and the aggregate water use for all water users upstream of the impact point. The General Standard criteria increase with increasing streamflow, therefore the graph shows the General Standard criteria increasing in the downstream direction as estimated streamflow increases.